§6. Theoretical Analysis of TAE in CHS

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Recently, Toroidicity-induced shear Alfvén Eigenmodes (TAE) have been observed in $L = 2/M = 8$ Compact Helical System (CHS) experiments. In order to clarify the properties of such TAE theoretically, the local and global mode analyses have been done.

Because of the toroidal field period of equilibria $M = 8$, CHS has $[M/2] + 1 = 5$ mode families, namely $N_f = 0, 1, 2, 3, 4$. Each mode family has independent shear Alfvén spectrum created by both poloidal and toroidal mode couplings, and experimentally $N_f = 1$ and 2 mode families are observed. In the high-mode-number limit, shear Alfvén spectrum of each mode family degenerates into one, which is analyzed in the local mode analysis by solving the high-mode-number ballooning equation. It is shown in the high-mode-number limit that the frequency of the 1st spectral gap corresponds to one created only by the poloidal mode coupling, and that the structure of the 1st gap, namely, the upper and lower bound frequencies and the discrete frequency in the gap (TAE), are almost independent of the label of the magnetic field line. In other words, influences of toroidal mode coupling on them are weak.

For the finite-mode-number, shear Alfvén spectrum of each mode family is different. The shear Alfvén continuum is shown in Fig.1 for $N_f = 1$ mode family, where an experimentally obtained MHD equilibrium is used. The toroidal mode coupling changes the envelop of the spectral gap dramatically, compared with one only due to the poloidal mode coupling. Especially, the radial interval of the spectral gap is shrinked strongly, which may lead to the continuum damping of TAE, if the effects of the toroidal mode coupling are strong.

The global mode analysis is performed by using 3-dimentional ideal MHD stability code: CAS3D3, in order to investigate influences of the toroidal mode coupling on TAE. Fig.2 shows one example of the eigenfunctions of the TAE for $N_f = 1$ mode family. The eigenfunction mainly consists of $(m, n) = (2, -1)$ and $(3, -1)$ modes. From the comparison between Fig.1 and Fig.2, it is understood that spiky structure due to the continuum hit is created only when the each mode hits the continuum with same toroidal mode number. Thus, we can see that the toroidal mode coupling does not cause strong continuum damping to TAE, although it makes complicated continuum structure.

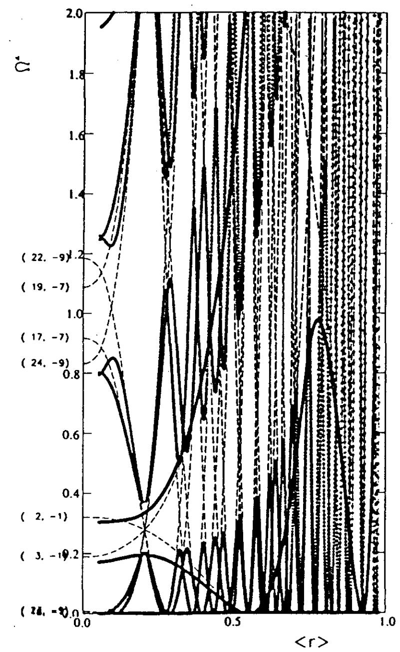

Fig.1 Radial distribution of shear Alfvén continuum for $N_f = 1$, and mode family, where dotted curves crrespond to continuum without mode couplings.

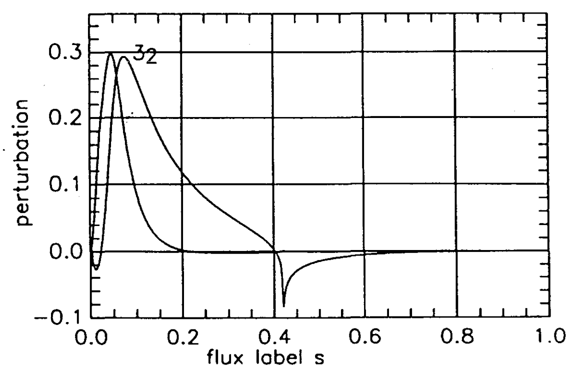

Fig.2 Radial distribution of TAE with $(m, n) = (2, -1)$ and $(3, -1)$ modes. The horizontal axis is r_N^2, where r_N is the normalized minor radius.